Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Solar Imaging Suite (SIS)

Statement of Work (SOW)

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

To verify the correct version of this document, please contact the GOES R Series Configuration Management Office.

Document Change Record

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Statement of Work (SOW)

Prepared By:

Cathy Richardson 5-7-04

Cathy Richardson, SIS Instrument Systems Manager **Date**

Reviewed By:

5/07/04

Fred G. Cunningham, Instrument Systems Manager **Date**

5/7/04

Andy Carson, NOAA Liaison **Date**

Approved By:

5/7/04

Martin A. Davis, GOES/POES Program Manager **Date**

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1. Scope

The acquisition of the Solar Imaging Suite (SIS) will follow a phased development strategy and will include two major phases: Formulation and Implementation. The work completed under this Statement of Work (SOW) for the Formulation Phase will be used as the foundation for the implementation contract to be awarded following completion of formulation. The SIS includes a Solar X-Ray Imager (SXI), an Extreme Ultraviolet Sensor (EUVS), and an X-Ray Sensor (XRS). These three instruments will be delivered by the SIS contractor mounted and co-aligned on a SIS Mounting Panel.

The Solar Coronagraph (SCOR) is a Pre-Planned Product Improvement instrument. Formulation phase only includes a requirements evaluation as defined in section 5.0 of this SOW. Unless specifically mentioned, other requirements in this SOW do not apply to the SCOR.

At implementation, the SCOR may become part of the SIS suite of instruments. The Government reserves the right to award a single contract for the SIS tasks including the SCOR or award a separate implementation contract for the SCOR, if it is selected for development.

This SOW specifies the requirements imposed on the vendors for performing work to complete the Formulation Phase of the SIS development. 18 months is being allocated for performance of the Formulation Phase.

1.1 Introduction

The SIS is being developed for the GOES program series of geo-synchronous satellites to replace and augment the current GOES N Series of solar viewing instruments. The SIS instruments have both threshold and goal requirements that are defined in the SIS PORD.

The Contractor **shall** give first priority to meeting the threshold requirements and **shall** then address the goal requirements.

The Contractor **shall** assess the resources (pointing, size, mass, power, data rate, risk and cost) of meeting just the threshold requirements and present the results at Progress Review 1 (PR#1).

The Contractor **shall** address the implications (pointing, size, mass, power, data rate, risk, schedule and cost) of moving toward or meeting the goal requirements.

1.2 Definitions

In the context of this SOW:

The term ***shall*** designates a mandatory requirement imposed upon the Contractor.

The term ***will*** designates a fact or the intent of the Government.

The term ***Configuration*** refers to the packaging of the SIS Suite.

The term ***Architecture*** refers to the methodology for performing the SIS tasks.

The term ***Approach*** refers to the methodology to be employed by the Contractor to meet the requirements of this SOW.

2.0 Reserved

3. Formulation Phase Reviews and Deliverables

The Contractor **shall** perform the reviews and reporting tasks listed below.

The Contractor **shall** provide deliverable products as specified below.

The format of the reviews will provide breaks for caucuses of the Government review team; mid-morning, mid-afternoon and following the formal presentation. The caucuses will be used to review the presentation and generate comments and questions for the Contractor, and to answer questions submitted by the Contractor that could not be answered from the floor. Questions that cannot be answered at the review by either party will be submitted in writing following the review.

Specific Action Items (AIs) or RFAs (Government Requests for Action) or Requests for Information (RFIs), that require extended time for response, may be generated at any review or by the Government at any time.

After contract award the Government will work with the Contractor to establish the review schedule to avoid conflicts with holidays and other commitments. At that time the delivery schedule in the contract will be adjusted.

3.1 Kick-Off Review

The Contractor **shall** hold a one-day kick-off meeting at the Contractor's facility approximately two weeks after contract award.

At this review:

The Contractor **shall** provide and present to the Government the draft System Engineering Management Plan for formulation.

The Contractor **shall** provide an outline of the planned formulation schedule with milestones.

The Contractor **shall** provide and present to the Government the draft Risk Management Plan for formulation and provide an initial assessment of risks that will be addressed during formulation.

The Contractor **shall** provide and present to the Government the draft Technology Readiness Plan for formulation with milestones.

The Contractor **shall** address the Requirements Traceability tool to be used for formulation and the implementation of the SIS development.

The Government will provide clarification of items in the PORD, GIRD, UIID and SOW to written questions received after contract start.

The Government will evaluate the draft plans and comment.

3.2 Progress Reviews

As provided in Section B of the Contract, there will be 3 one-day Progress Reviews (PRs) held at the Contractor's facility, in accordance with the schedule presented in Section 3.7.2 of this SOW.

The Government and the Contractor will establish the review agendas jointly. The concept is that the Contractor will submit the agenda approximately two weeks prior to the review, and the Government will add additional items to be addressed, if any.

The Contractor **shall** submit the draft Progress Review Data Package in electronic format one week prior to the review.

At these reviews:

The Contractor **shall** present the results of the work performed since the previous review.

The Contractor **shall** discuss relevant technical and programmatic issues and findings.

The Contractor **shall** describe at PR #1 the analytical models to be used, and simulations planned for the formulation as well as implementation phases of the SIS development.

The Contractor **shall** identify, at each review, opportunities to reduce and retire risk to performance, schedule and/or cost, and opportunities to compress schedule or cost by recommending specific requirements changes.

The Contractor **shall** provide a rationale for each recommended change to the requirements.

3.3 Midterm Review

The Midterm Review (MTR) will be a two-day review held at the Contractor's facility approximately 10 months after contract award, after initial completion of trade studies. *(ECR 0006)*

The Contractor **shall** submit the draft MTR Data Package in electronic format two weeks prior to the review.

At this review:

The Contractor **shall** present the results of trade studies and analyses.

The Contractor **shall** present the initial SIS concepts that were used as the basis for trade studies.

The Contractor **shall** evaluate all requirements and recommend which requirements are not practical due to risk, mass, volume, data rate and power considerations, and provide alternatives to the requirements and/or constraints.

The Contractor **shall** deliver final System Engineering Management, Risk Management, and Technology Readiness Plans for formulation.

The Contractor **shall** address the status and key results to date of all items identified in SOW Section 4.1., 4.2, 4.2.1, 4.2.2, 4.2.3, 4.2.4 and 4.2.5.

The Contractor **shall** present a Recommended Approach (RA), the configuration and architecture that is to be brought to a concept design.

The Contractor **shall** present a rough order of magnitude cost estimate for the development and production for the Recommended Approach of four SIS flight models, one Engineering Development Unit (EDU), and one SIS prototype unit. *(ECR 0006)*

The Government will release the final requirements approximately three months following the MTR.

Following release of the final requirements the Government will answer any clarification questions provided the questions are submitted in writing. Contractors should submit their questions to the Government within two weeks after release of final requirements. Responses to the questions will be provided to all formulation contractors.

3.4 Formulation Phase Concept and Cost Review

The Formulation Phase Concept and Cost Review (FPCCR) will be a three-day review held at the Contractor's facility approximately 17 months after contract award.

The Contractor **shall** submit the FPCCR draft Data Package in electronic format 2 weeks prior to the review.

At this review:

The Contractor **shall** present the results of the work performed under the contract.

The Contractor **shall** present a summary of all analyses and trade studies.

The Contractor **shall** present the Concept Design developed as a result of the formulation studies.

The Contractor **shall** present (in a separate document) an estimate of costs for implementation, broken down to level four of the Work Breakdown Structure (WBS), using the Contract WBS provided by the Government after the MTR, which will be used for the balance of formulation and for the implementation phase. The cost information will not be presented at the open review, just an overview of the process.

The Contractor **shall** convene a separate review following the FPCCR, to discuss the cost information with Project Management.

The Contractor **shall** discuss and deliver to the Government the draft version of those plans to be used during the Implementation Phase that are listed on the Document Delivery List.

The Contractor **shall** address all topics listed in Section 4.2.5 through 4.3.6 of this SOW.

3.5 Action Item Review

The Action Item Review (AIR), to be held at the Goddard Space Flight Center, will be a one-day review held approximately one month following the FPCCR. The AIR will be the final event in the formulation study and will be used to wrap up any action items or other issues remaining after the FPCCR.

The Contractor **shall** present closure to Action Items (AIs) remaining from the FPCCR.

At the AIR the Government will identify residual weaknesses found in the Concept Design, draft implementation plans, trade studies and analyses.

3. 6 Final Report Package

The Final Report Package will consist of:

- The FPCCR package with facing page text including any changes due to action items from the FPCCR.
- A compilation of all products that document the work performed under the Formulation Phase Contract.

3.7 Contract Deliverables

3.7.1 Document Delivery

The Contractor **shall** deliver the following documents as specified.

Deliverable Item	**Delivery Date**
• Draft Systems Engineering Management Plan – formulation	At Kick-off Review
• Draft Risk Management Plan – formulation	At Kick-off Review

• Draft Technology Readiness Plan - formulation	At Kick-off Review
• Formulation Schedule	At Kick-off Review
• Master Action Item Data Base	Start ACA*
• Requirements Traceability Matrix – formulation	At PR #1
• Decision Matrix - formulation	At PR #1
• Midterm Review Data Package, draft	2 weeks before MTR
• Trade Study and Systems Analysis Reports	As generated
• Technology Readiness Plan – formulation	At MTR
• Risk Management Plan – formulation	At MTR
• Systems Engineering Management Plan – formulation	At MTR
• Recommended Work Breakdown Structure, - implementation	At MTR
• Implementation Phase Schedule, draft	At MTR
• Systems Engineering Management Plan, draft - implementation	With FPCCR data package
• System Performance Verification Plan, draft - implementation	With FPCCR data package
• Program Management Plan, draft - implementation	With FPCCR data package
• Configuration Management Plan, draft - implementation	With FPCCR data package
• Technology Readiness Plan, draft - implementation	With FPCCR data package
• Financial Management Plan, draft - implementation	With FPCCR data package
• Risk Management Plan, draft – implementation	With FPCCR data package
• FPCCR Package	2 weeks before FPCCR
• Concept Design	At FPCCR
• Cost Estimates	At FPCCR
• Updated Implementation Phase Schedule, draft	At FPCCR
• SCOR Requirements Evaluation	At FPCCR
• Requirements Traceability Matrix, draft - implementation	At AIR
• Decision Matrix, Draft – implementation	At AIR
• Final Report package	At AIR

3.7.2 Reviews

Description	Quantity	Delivery Date

• Kick-off Review	1	2 weeks ACA
• Progress Review #1	1	3 months ACA
• Progress Review #2	1	7 months ACA
• Midterm Review	1	10 months ACA
• Progress Review #3	1	14 months ACA
• FPCCR	1	17 months ACA
• Action Item Review	1	18 months ACA

*ACA = After Contract Award *(ECR 0006)*

3.7.3 Acceptance of Contract Deliverable Items

The Contracting Officer's written determination that Government Requests For Action (RFAs), Request For Information (RFIs), other Action Item (AI) closures, and other deliverable reviews and products, have been closed out or completed will constitute acceptance of the deliverable.

3.8 Contractor Web Page

The Contractor **shall** establish a secure web site, with remote access by the Government for retrieval of required documents, e.g., Technical Analyses, System Trade Study Reports, data packages, etc., and for exchange of other competition sensitive information.

4. Formulation Tasks

The Formulation Phase is partitioned into three segments: Segment one ends with the MTR, segment two ends with the FPCCR, and Segment three ends with the AIR.

4.1 General

The Contractor **shall** complete the following three segments of study that comprise the Formulation Phase of the SIS development:

- Systems Requirements Analysis, Configuration Trade and Architecture Trade Studies, System Trade and Requirements Baseline Studies (MTR)
- Conceptual Design of a SIS instrument (FPCCR)
- Closeout with AIR

The Formulation Phase requires both technical as well as program management effort and will result in a final definition of requirements and the submission of a concept design that may be the basis of the contractor's implementation proposal.

The intent of segment 1 of the study is to determine the feasibility of meeting the threshold requirements of the SIS PORD, and the implications of the goal requirements and their impact on instrument mass, volume, power, data rate, associated risks and cost. **The notional baseline of a distributed (multi-sat) system with co-manifested launches, which is currently under study, has introduced significant instrument mass and volume constraints as captured in the SIS UIID**. These studies are designed to enable the Government to: (1) Update and refine mission requirements

throughout the sequence of scheduled reviews; (2) reduce the requirements trade space, and define or bound the configuration and architecture baselines following completion of the MTR; and (3) issue final requirements approximately three months following the completion of the MTR. The intent of segment 2 is to provide concept designs for potential implementation from each contractor. Segment 3 closes out the formulation phase with closure of Action Items and identification of weaknesses to each contractor.

4.2 Systems Engineering

The Contractor **shall** use a disciplined Systems Engineering Process (SEP) for the performance of all tasks within this SOW.

The Contractor **shall** develop and implement a systems engineering management process and document the process within a Systems Engineering Management Plan (SEMP) to complete the Formulation Phase.

The SEMP **shall** define the necessary tasks and activities to be performed to complete the following systems engineering tasks:

- Requirements analysis
- Functional analysis, allocation and derivation
- Synthesis for the system Concept Design.

The Contractor **shall** use the SEP to transform the requirements stipulated in the PORD, GIRD, UIID and MAR into a design process that addresses the following elements for the Concept Design:

- Systems design
- Systems development
- System fabrication
- Systems test and evaluation
- Operational deployment

4.2.1 System Requirements Analysis

The Contractors Systems Requirements Analysis **shall** address the following general requirements:

- Analysis of the SIS mission, performance, technical, operational and interface requirements as stated in the PORD, GIRD, UIID and MAR;
- Development of a Traceability Matrix of all requirements from the PORD, GIRD, UIID and MAR to the Contractor's derived and allocated requirements for the SIS Instrument;
- Development of a Decision Matrix with an audit trail from requirements to analysis to Concept Design, including key decisions made and their rationale;
- Development of a verification and validation methodology designed to demonstrate that the Concept Design meets requirements;
- Development and maintenance of a Master Action Item Database (MAID) listing all RFAs from formal reviews, Government status reviews, internal technical reviews, peer reviews, and

telecons, listing author of the RFAs, person responsible for closure, wording of the RFA, response, person(s) authorizing final closure, and date closed.

The Contractor **shall** conduct trade studies, trade-off analyses, risk analyses and cost-effectiveness analyses to ensure that a thorough and comprehensive set of options and alternatives is considered and analyzed for design, with consideration for all aspects of the system life cycle and all aspects of system life cycle cost.

4.2.2 Systems Requirements Baseline

The Contractor **shall** identify the schedule, cost, and risk drivers of the SIS instruments design requirements.

The Contractor **shall** evaluate all requirements and recommend at the MTR modifications that would significantly reduce the size, mass, power, data rate, technical concerns, associated risks, and costs.

The Contractor **shall** evaluate all requirements, in the range between threshold and goals, in terms of performance, risk, and system resources.

The Contractor **shall** recommend, at the MTR, modifications to establish firmer performance limits for the requirements to help bound the trade space.

The Contractor **shall** propose requirement values, and the associated rationale, for all parameters listed as “TBD” or "TBR" within the SIS requirements documents, no later than the MTR.

The Contractor **shall** quantify potential cost impacts of the recommended requirements changes, on an absolute and relative cost basis, measured in FY 2004 dollars.

4.2.3 Trade Studies and General Analyses

The Contractor **shall** perform the trade studies listed below and other trade studies as the Contractor chooses.

The Contractor **shall** include the following information in each Trade Study Report:

- Evaluation of how the trade-offs impact potential SIS design concepts;
- Evaluation of technical performance, schedule and cost risks;
- Evaluation of impact on system mass, power, volume, contamination requirements, and data rate;
- Evaluation of the impact of micrometeorites on the reliability of the instruments.

The Contractor **shall** complete all trade studies required by the contract prior to the MTR.

The Contractor **shall** develop a Recommended Approach (RA) for the SIS.

The Government may provide comment on the RA, but the Contractor is encouraged to proceed to concept design with the approach of **its** choice.

The Government may select baseline changes to performance requirements and system resources, after the MTR, if the results of TS1 through TS5 identify a configuration or architecture that would have acceptable risk to the SIS.

It is not the Government's intent to encourage or require a contractor to carry multiple architectures or multiple configurations to concept design. To do so would dilute the value of each effort.

TS1: Requirements Analysis, System Configuration and Architecture Trade Study

The Contractor **shall** complete Trade Study TS1 prior to the MTR.

The Contractor **shall** evaluate instrument configurations and architectures necessary to meet the SIS threshold requirements while minimizing risk.

The Contractor **shall** evaluate different configurations for the SIS electronics boxes. These **shall** include, as a minimum, the electronics boxes mounted on the SIS mounting panel, the electronics boxes mounted on the yoke, and the electronics boxes mounted on the spacecraft body. The Contractor **shall** provide impacts on all interfaces for each configuration studied.

The Contractor **shall** develop a configuration modular in concept that allows for technology and performance upgrades as SIS requirements evolve.

The Contractor **shall** include estimates of mass, size, power, data rate, technical performance, associated risks and cost for each configuration and architecture studied.

The Contractor **shall** identify the features in heritage instruments that can be used to reduce risk in the SIS development.

The Contractor **shall** evaluate the pointing requirements of the instruments and their sensitivity to disturbances (both spacecraft disturbances and self-induced disturbances) and determine the best approach to meet them.

The Contractor **shall** develop a set of requirements for contamination control.

The Contractor **shall** recommend requirement relaxations that would significantly mitigate technical, schedule and cost risks.

The Contractor **shall** identify goal requirements that could be approached, met or exceeded with minimal risk.

TS2: SXI Architecture Trade Study

The Contractor **shall** study at least two architecture alternatives for the SXI, described as Option A and Option B below. The trade **shall** include how the DEM reconstruction will be achieved for each option studied.

The objective is to provide intensity measurements in a set of wavelength ranges that most effectively allow retrieval of the Differential Emission Measure (DEM) defined in the PORD. Different technical approaches are possible such as the two described below. Option A represents a possible set of broad, soft X-ray bands. Option B represents a set of narrow, extreme ultraviolet bands. Potential bands for each option are provided in the following table.

Potential Spectral Bands

	Option A	Option B
Band	Approximate Wavelength (nm)	Wavelength (nm)
A	0.6-10.0 nm	17.45 (Fe X)
B	0.6-8.0 nm	21.10 (Fe XIV)
C	0.6-5.0 nm	33.50 (Fe XVI)
D	0.6-2.0 nm	9.40 (Fe XVIII)
E	0.6-1.6 nm	19.30 (Fe XII & XXIV)
F	0.6-1.2 nm	13.10 (Fe VIII & XX)

The temperature response of Option A is broad while the temperature response of Option B is narrow. Thus, while the peak response of Option A may not be at LogT=6.0, substantial response still exists at that temperature. The selected bands and response **shall** allow the reconstruction of DEM curves shown in the table in the SIS PORD, modeled for different solar features, to be accomplished from LogT=5.7 to LogT=7.2 with the uncertainties specified. DEM reconstruction **shall** be accomplished using the hybrid abundances of Fludra and Schmelz (The absolute coronal abundances of sulfur, calcium, and iron from Yohkoh-BCS flare spectra, *Astronomy and Astrophysics*, *348*, 286-294, 1999), the ionization equilibrium of Mazzotta et al. (Ionization balance for optically thin plasmas: Rate coefficients for all atoms and ions of the elements H to NI, *Astronomy and Astrophysics Supplement Series*, *133*, 403-409, 1998), and the APEC/APED spectral model of Smith et al. (Collisional Plasma Models with APEC/APED: Emission-Line Diagnostics of Hydrogen-like and Helium-like Ions, *Astrophysical Journal*, 556, L91-L95, 2001.). DEM reconstruction uncertainties **shall** be computed using Monte Carlo simulation with a noise model of appropriate fidelity, e.g. including photon statistics, detector read noise, etc. An appropriate curve-fitting algorithm (TBD) **shall** be used to obtain a smooth DEM reconstruction.

The Contractor **shall** present the DEM reconstruction approach at the Kick-Off Meeting.

The Contractor **shall** present the derived instrument requirements that will be used for the Trade Study at PR #1. At a minimum, these requirements **shall** include the bands that will be measured for the reconstruction of the DEM.

TS3: EUVS Architecture Trade Study

The Contractor **shall** study at least two architecture alternatives for the EUVS: Option 1) a band-pass filter based instrument and Option 2) A grating based instrument. All other parameters in the PORD **shall** be met.

Observational parameter	Option 1	Option 2
Spectral Range	5 to 127 nm	17 to 40 nm
Spectral Bands or Spectral Resolution	6 Spectral Bands EUV-A 5 – 15 nm EUV-B 15 – 25 nm EUVS-C 25 – 34 nm EUVS-D 35 – 55 nm EUVS-E 65 – 95nm EUVS-F 118-127 nm	0.5 nm spectral resolution
Measurement Resolution	0.25%	4%

(ECR 0002)

TS4: Calibration Methodologies Trade Study

The Contractor **shall** evaluate instrument calibration methodologies for each instrument in the Solar Imaging Suite for the following stages of development; ground test and evaluation, performance and functional verification, pre-launch operations and on-orbit operations.

TS5: Additional trade studies as proposed by the Contractor.

The Contractor **shall** define the additional trade studies to be performed in the proposal.

Additional trades must be incorporated as Attachment H of the Contract.

4.2.4 Tool Development

The Contractor **shall** utilize a requirements traceability tool to track the flow down of requirements to the subsystem or lower level. The GOES-R Project is using DOORS.

The Contractor **shall** use the tool to demonstrate that the SIS conceptual design meets all requirements.

The Contractor **shall** develop simulations and analytical tools, including a photometric mathematical model, in support of the conceptual design and trade study effort. This does not include retrieval algorithms.

The Contractor **shall** use these tools throughout the SIS Formulation and Implementation Phases.

It is the intention of the government to make these analytical tools, simulations and models deliverable items early in the implementation phase by the selected SIS Contractor, and to have these tools supported and updated by the SIS Contractor throughout the implementation phase.

4.2.5 Simulation

The Contractor **shall** use the simulation tools to demonstrate that the expected performance of the Concept Design meets performance requirements.

The Contractor **shall** demonstrate data decompression and calibration algorithms at the full data rate of the SIS.

The Contractor **shall** include in the simulation models of SIS the instrument to spacecraft transfer function and estimated spacecraft pointing errors.

The Contractor **shall** use the simulation tools to estimate the computer resources necessary to provide the Level 1b data products (calibrated products) by the MTR.

4.2.6 Concept Design and Related Analyses

The Contractor **shall** develop a Concept Design for SIS addressing all requirements contained in the PORD, GIRD, UIID and MAR.

The Contractor **shall** perform engineering analyses to justify design parameters, tolerances, and design/performance margins, and to support required trade studies.

The Contractor **shall** maintain a Government provided physical parameter sheet that includes performance, mass and power breakdowns by subsystem and component.

A template of the draft parameter sheet will be provided at the Kick-Off Review.

The Contractor **shall** provide a systems block diagram.

(1) Mechanical

The Contractor **shall** provide a mechanical layout drawing.

The Contractor **shall** provide a preliminary mechanical and structural analysis demonstrating size and mass margins, instrument sensitivity to dynamic and shock loads, and sensitivity to self induced and spacecraft induced disturbances.

(2) Power System

The Contractor **shall** provide a preliminary analysis of the power system requirements of the Concept Design.

(3) Command and Telemetry

The Contractor **shall** provide a preliminary analysis of the Command and Telemetry architecture including onboard memory and stored commands, onboard processing, engineering and science data flow and data compression.

The Contractor **shall** provide an assessment of the implications of a 1553 spacecraft interface on the SIS concept design.

The Contractor **shall** provide an assessment of the implications of an RS422 spacecraft interface on the SIS concept design.

(4) Thermal

The Contractor **shall** provide a preliminary analysis of the thermal control system showing planned heat flow to the spacecraft and instrument radiators, designed operating temperature range and radiator sizing.

(5) Fault Detection

The Contractor **shall** provide a preliminary analysis of the Fault Detection and Correction methodology proposed for the Concept Design to prevent failures due to Single Event Upsets (SEUs) and Single Event Latch-ups (SEL) events.

(6) Calibration

The Contractor **shall** define the proposed calibration methodology for the SIS (both pre-launch and post launch).

The Contractor **shall** develop a conceptual design for instrument calibration.

The Contractor **shall** provide a photometric analysis, with documentation, for the recommended approach.

The Contractor **shall** identify all photometric errors, e.g., those produced by non-Gaussian noise, shot noise, white noise, 1/f noise, popcorn noise, thermal drifts of the detectors, optical elements, misalignment, jitter, polarization, and variations in the SIS optical throughput over its field of regard.

The Contractor **shall** discuss the mitigation of these photometric errors as a function of the frequency of onboard calibration measurements.

(7) Instrument Pointing

The Contractor **shall** define a systems approach for meeting all pointing requirements specified in the PORD, given the spacecraft interface specification contained in the GIRD and UIID.

The Contractor **shall** develop pointing error budgets.

The Contractor **shall** provide supporting analysis for the error budgets and derived requirements.

(8) Software

The Contractor **shall** define the software architecture for the SIS instrument that includes flight software and ground system software for instrument operation and test.

The Contractor **shall** define the software functions and processes and include estimates for software lines of code (SLOC) with estimates for new, modified and any re-use SLOC.

(9) Detectors

The Contractor **shall** develop a design concept for the focal planes proposed for the Concept Design.

The Contractor **shall** provide an estimate of detector performance required to meet instrument requirements.

The Contractor **shall** assess detector performance as a function of detector temperature and temperature stability.

(10) Field of View

The contractor **shall** develop the requirements for a clear field of view for the SIS instruments.

(11) Reliability and Lifetime

The Contractor **shall** perform a preliminary reliability analysis to demonstrate that the conceptual design can meet its required lifetime.

The Contractor **shall** identify all single point failure and fault critical elements.

The Contractor **shall** describe the fault tolerant/graceful degradation features of the design.

(12) Verification and Testing

The Contractor **shall** develop a draft System Performance Verification Plan (SPVP) and a draft Environmental Verification Plan in accordance with the IMAR, and that addresses verification of both the protoflight model and flight model instruments.

The Contractor **shall** emphasize the verification approach and Ground Support Equipment (GSE) to be used for calibration and life testing of mechanisms and other potential life limited items.

(13) Ground Support Equipment

The Contractor **shall** identify the GSE for use during instrument development, spacecraft integration and test and at the launch site, including a description of all hardware, software, tooling, handling and logistical components.

(14) Data Processing

The Contractor **shall** develop algorithms for data compression and calibration.

The Contractor **shall** determine the lowest possible data rate that satisfies all requirements using data compression without degradation of the data.

The Contractor **shall** present, at the FPCCR, expected performance of these algorithms and their rationale for selection.

The Contractor **shall** estimate the processing load required to implement the ground-processing portion of these algorithms.

4.2.7 Technology Assessment and Demonstration

The Contractor **shall** finalize, at the FPCCR, the assessment of technology readiness for SIS implementation. The minimum acceptable technology readiness criterion is defined as Technology Readiness Level TRL 6 by the Implementation Phase PDR.

The Contractor **shall** provide a detailed Technology Readiness Plan to be carried out during the formulation phase to validate all technologies not deemed to be ready for the implementation phase.

The Contractor **shall** clearly identify and justify any validation that is expected to continue into the implementation phase.

The Contractor **shall** address risks associated with delayed validation in the Risk Management Plan.

The Contractor **shall** demonstrate through breadboards, prototypes, and similar validation techniques that all required technologies can be brought to TRL 6 by the required time.

The Contractor **shall** provide a draft Technology Readiness Plan for implementation.

A TRL Definition Table is provided in the Appendix.

4.3 Project Management

The Contractor **shall** develop a draft Project Management Plan (PMP) for the Implementation Phase of SIS development to ensure that there is an appropriate balance of workforce for all work associated with this SOW and, to include projections for the complete development and operation of the SIS instruments.

4.3.1 Project Planning and Control

The Contractor **shall** provide a draft Work Breakdown Structure (WBS) for implementation by the MTR.

The Government will review and establish a Contract WBS for implementation.

The Contractor **shall** provide cost estimates for implementation, to level four of the WBS, that address both absolute costs (the achievement of a specific performance) and relative costs (the cost delta between required performance and the Contractor's proposed design performance).

The Contractor **shall** define the cost estimation techniques that will be used during formulation to provide a cost estimate for the Concept Design by PR # 1.

The Contractor **shall** perform cost analyses in support of all other trade studies and analyses required during the study period.

The Contractor **shall** perform time-phased cost analyses for development and production of four SIS flight models, one Engineering Development Unit (EDU) and one SIS prototype unit.

The Contractor **shall** separately identify costs for unique GSE required for instrument procurement, fabrication, integration and test, calibration, spacecraft-level integration and test, and launch and on-orbit checkout activities, including logistics.

The Contractor **shall** use the Mission Assurance requirements stated in the implementation phase IMAR in developing the cost estimate for the implementation phase.

The Contractor **shall** provide a draft Implementation Phase schedule by the MTR, showing PDR, CDR, and delivery of the EDU, the prototype unit and the four flight models.

The Contractor **shall** update their draft Implementation Phase schedule at the FPCCR.

4.3.2 Supplier and Subcontractor Control

The Contractor **shall** define and document a Supplier and Sub-Contractor Management System, which **shall** be part of the PMP.

The Contractor **shall** recommend a parts procurement strategy that addresses procurement of long-lead items and impact of late delivery on the implementation schedule.

The Contractor **shall** recommend a parts procurement strategy that will provide sufficient spares throughout the life of the program.

4.3.3 Configuration Management

The Contractor **shall** define a Configuration Management System (CMS) for the complete life cycle of the SIS development.

The Contractor **shall** provide a draft Configuration Management Plan (CMP) that includes all processes and descriptions of procedures to be implemented.

4.3.4 Financial Management

The Contractor **shall** provide a draft Financial Management Plan (FMP) for implementation that includes a Performance Measurement System with Earned Value, Cost Variance and Schedule Variance reporting to provide cost and schedule management for the entire life cycle of the SIS instrument program.

The Contractor **shall** correlate the FMP to the Government supplied, Implementation Phase Contract WBS.

4.3.5 Risk Management

The Contractor **shall** provide and implement a Risk Management Plan (RMP) for the Formulation Phase. NASA NPG 8000.4 may be used as a guide.

The Contractor **shall** provide a draft RMP for the Implementation Phase.

The Contractor **shall** identify and assess risks to the development of the SIS.

The Contractor **shall** use Failure Mode Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Failure Mode Effects and Criticality Analysis (FMECA), as appropriate, to analyze and/or identify system and/or component risks.

The Contractor **shall** identify and prioritize the technical and programmatic risks that represent the greatest threat to the program.

The Contractor **shall** implement the actions (mitigate, watch or research) necessary to eliminate or reduce the likelihood or consequences of the identified risks and identify alternate implementation paths.

The Contractor **shall** identify risks in the Concept Design and address them in the RMP.

The Contractor **shall** investigate and incorporate in the RMP, as appropriate, lessons learned from previous instrument development efforts, both from the experience of the Contractor and from other sources.

The Contractor is encouraged to enter lessons learned during the Formulation Phase into the GOES lessons learned information system. (TBS).

4.3.6 Contamination Control

The Contractor **shall** develop a Contamination Control Program to ensure that the SIS instrument(s) are not contaminated by molecular and particulate contaminants, both on the ground and on-orbit, to an extent sufficient to cause degradation of performance below the required levels

The Contractor **shall** provide a draft Contamination Control Plan (CCP) for the Implementation Phase.

5.0 Solar Coronagraph (SCOR) Requirements Evaluation

The Contractor **shall** perform a Requirements Evaluation on the SCOR.

The Contractor **shall** consider in the evaluation all requirements stated in the SCOR PORD, the SCOR UIID, the MAR and the GIRD and evaluate their impact on interface requirements including pointing, mass, volume, power, data rate, glint free field of view, and contamination requirements.

The Contractor **shall** evaluate all requirements and recommend which requirements are not practical due to mass, volume, data rate and power considerations, and provide alternatives to the requirements and/or constraints.

The Contractor **shall** present options that would allow the mounting of one or more of the SIS instrument on the same mounting panel as the SCOR. Any necessary changes to the concept designs of the SXI, EUVS, and XRS **shall** be identified.

The Contractor **shall** provide status of the SCOR Requirements Evaluation at each Progress Review and at the MTR.

The Contractor **shall** present the final results of the SCOR Requirements Evaluation at the FPCCR and include the results in the Final Report.

APPENDIX

Technology Readiness Levels

TRL 1 **Basic principles observed and reported:** Basic scientific principles established. Initial translation to applied R&D. Mix of basic and applied research.

TRL 2 **Technology concept and/or application formulated:** Identification of potential applications, in advance of experimental proof or detailed analysis. Mostly applied research.

TRL 3 **Analytical and experimental critical function and/or characteristic proof-of-concept:** Laboratory studies to validate analytical predictions. Scientific feasibility fully demonstrated.

TRL 4 **Module and/or subsystem validation in laboratory environment:** Standalone prototype implementations. Experiments with integration of elements to validate system concepts.

TRL 5 **Module and/or subsystem validation in relevant environment:** Significant improvement in fidelity of testing and integration. Prototype implementations conform to final environment. Experiments with realistic data. Simulated interfaces to existing systems.

TRL 6 **System/Subsystem prototype demonstration in a relevant end-to-end environment:** prototype implementations on full scale realistic problems. Brassboard demonstrations in relevant environment (in space, if necessary). Engineering feasibility fully demonstrated.

TRL 7 **System prototype demonstration in high-fidelity environment (parallel or shadow mode operation):** Operational prototype, near or at the scale of the final system. Often done less for technology R&D than for system engineering and management confidence.

TRL 8 **Actual system completed and system "mission qualified" through test and demonstration in an operational environment:** All functionality tested in operational scenarios through integration with existing systems. Verification and validation completed.

TRL 9 **Actual system "mission proven" through successful mission operations:** Post implementation confirmation of system performance. Actual system fully demonstrated.